

Peer review history of the paper *Not all elementary school teachers are scared of math* by Christina Artemenko, Nicolas Masson, Carrie Georges, Hans-Christoph Nuerk, & Krzysztof Cipora published in Special issue *Direct and Conceptual Replication in Numerical Cognition* in *Journal of Numerical Cognition* (vol 7, 3). <https://doi.org/10.5964/jnc.6063>

## Table of Contents

<b>Initial decision letter .....</b>	<b>1</b>
<b>Authors' response .....</b>	<b>3</b>
<b>Second decision letter .....</b>	<b>11</b>

## Initial decision letter

Dear Christina and colleagues,

I had invited two reviewers to evaluate your submission to Journal of Numerical Cognition, "Not all elementary school teachers are scared of math". I received feedback from one of them. The other one ultimately wasn't able to provide feedback. I decided not to let you wait longer and based myself on the one review that I received. This reviewer was very positive, and my own reading confirms this view. Yet, the reviewer also raised a few points which can help you further improve the quality of the paper. I am inviting you to address these points in a revision. I consider these revisions to minor, so if you are able to convince me that you have adequately responded to the reviewer's points, I will not send it out for an additional review round.

-----

Reviewer B:

Comments for author(s):

### Summary

This study deals with the presence of math anxiety in pre and in-service elementary school teachers. The study-setup was straightforward: elementary school teachers and students that were training to become an elementary school teacher were approached via an online questionnaire where math anxiety was measured together with other (demographic) variables and tasks. More precisely the effect of the factors gender, teaching experience, math specialization and attitudes towards teaching math were investigated. All data were compared to a large control group of university students (with different backgrounds). The aim was to replicate several previous findings of studies that were conducted in other countries, as the prevalence of math anxiety seems to differ between countries. The results were clear-cut. They replicated the previous finding by showing that female elementary school teachers have a higher level of math anxiety as compared to other female students. Importantly, female elementary school teachers without math specialization had higher levels of math

anxiety than female students from other fields. In contrast, female elementary school teachers with math specialization did not show an increased level of math anxiety. Teaching experience did not exert an influence.

### Evaluation

The paper deals with a very interesting and relevant topic, which for sure would fit within the Journal of Numerical Cognition. The paper is well written, hypotheses were properly framed and clearly formulated. The methods are sound and overall, the analyses are well described (although some information should be added, see below). In the general discussion the results are properly discussed and linked back to the literature, although to fully support some interpretations, this additional information would be welcome. Thus overall, I think the paper is of good quality, and would be suitable for the journal. However, before accepting the paper, I'd like to mention a couple of major and minor remarks I had while reading the paper, which I'd like to see addressed.

The most important one is that the paper does not contain information about the years of experience of the in-service group, and about the grade in which they are teaching. As the content of a math course in 1st year is much less difficult than the content in the last year of elementary school, I can imagine that these factors can be important mediators of the interactions reported in the paper. For example, maybe math specialization does not influence math anxiety so much for those who have to teach the basics of math to young children, while this can be the case when teaching more complex issues in the last year of elementary school. The same holds for experience. It will probably only after a couple of years of teaching that the confidence towards teaching math will grow. If the current sample mainly contains young teachers, then the conclusion that experience has no influence on math anxiety might be wrong. Also, for the pre-service group, it is not reported in which year of their training they were. This is in my opinion also important information because of a strong selection takes place in the first years of educations (maybe math anxiety is much more present in the 1st year of teacher training, because the students with severe math anxiety will more likely fail for math related courses and therefore not pass).

Second, in the paper only group analyses were reported, and as a group the teachers have higher levels of math anxiety compared to the control group. This does however not mean that they suffer from pathological levels of anxiety. Actually, when looking at the figures, the effect-size is rather small, so that you can wonder whether it had "clinical" significance. In the introduction it is frequently stated that math anxiety has a detrimental effect on math performance and teaching and creates the chance of a spillover of the anxiety towards children. Importantly, it is possible that healthy levels of anxiety can be advantageous (as it can motivate you to work harder). In this context, it is not sufficient to say that elementary school teachers have, as a group, higher levels of math anxiety. Given the presence of a relevant control group, it would be interesting to know how many in- and pre-service teachers score higher than e.g. pc. 90 of the control group. I think this information can provide additional interesting information to further strengthen the conclusions of the paper.

Where I fully understand that introducing more levels to certain variables (e.g. grade of teaching, years of experience) will give rise to lower numbers of participants in certain cells of the design, I'd like to hear the authors response to these issues and hope to be reassured that these factors do not fundamentally change some of the

conclusion. As you can see below, some of the conclusions mentioned in the general discussion can, in my opinion, only be fully appreciated when this missing information is provided.

Below I'll give a "chronological" overview of the (minor) comments that came to my mind while reading the manuscript.

#### Introduction

- P3 line 3: Strange formulation. If something has been shown in a meta-analysis, it should also be found in individual studies.
- P3, line 17. Maybe it is interesting to mention the observed % of the different countries
- P6, line 12: Can you be more specific with what you mean with math specialization? Are there additional math courses, or additional courses in how to teach math? Are these courses part of the curriculum? How is specialization in math during secondary education defined?
- P8 line 28 Were the subjects aware that their mathematical abilities were going to be measured? Was this indicated in the informed consent, or in the general description of study?
- P9 line 9. Please provide the average AMAS scores
- P10 line 2: Why are the results anecdotal and inconclusive, and how can this be seen in the figure and table?
- P11 figure: please indicate what the grey zone means.
- P14, line 7-8: "depending on specialization but not experience", For this conclusion more information is needed about the years of education, grade where the type of specialization
- P15, line 20: "... might not fade away with increased teaching experience." -> this conclusion only makes sense when you know the average age of experience.
- P16 line 1: I think you have to be careful with this interpretation. There is a potential methodological problem. The questions about joy and ease of teaching are asked at the end of the questionnaire. Isn't it possible that responses are biased by the anxiety questionnaire? People are sensitive to potential inconsistencies in their responses. I can't imagine that you will say that you enjoy teaching math a lot when you just indicated that math makes you anxious. Maybe you can mention this as a limitation of the study?
- P16, line 19: this conclusion can also only be fully appreciated if information about the level of experience and the grade in which they were teaching is known.

## Authors' response

Reviewer B:

Comments for author(s): Summary

This study deals with the presence of math anxiety in pre and in-service elementary school teachers. The study- setup was straightforward: elementary school teachers and students that were training to become an elementary school teacher were approached via an online questionnaire where math anxiety was measured together with other (demographic) variables and tasks. More precisely the effect of the factors

gender, teaching experience, math specialization and attitudes towards teaching math were investigated. All data were compared to a large control group of university students (with different backgrounds). The aim was to replicate several previous findings of studies that were conducted in other countries, as the prevalence of math anxiety seems to differ between countries. The results were clear-cut. They replicated the previous finding by showing that female elementary school teachers have a higher level of math anxiety as compared to other female students. Importantly, female elementary school teachers without math specialization had higher levels of math anxiety than female students from other fields. In contrast, female elementary school teachers with math specialization did not show an increased level of math anxiety. Teaching experience did not exert an influence.

## Evaluation

The paper deals with a very interesting and relevant topic, which for sure would fit within the Journal of Numerical Cognition. The paper is well written, hypotheses were properly framed and clearly formulated. The methods are sound and overall, the analyses are well described (although some information should be added, see below). In the general discussion the results are properly discussed and linked back to the literature, although to fully support some interpretations, this additional information would be welcome. Thus overall, I think the paper is of good quality, and would be suitable for the journal. However, before accepting the paper, I'd like to mention a couple of major and minor remarks I had while reading the paper, which I'd like to see addressed.

The most important one is that the paper does not contain information about the years of experience of the in- service group, and about the grade in which they are teaching. As the content of a math course in 1st year is much less difficult than the content in the last year of elementary school, I can imagine that these factors can be important mediators of the interactions reported in the paper. For example, maybe math specialization does not influence math anxiety so much for those who have to teach the basics of math to young children, while this can be the case when teaching more complex issues in the last year of elementary school. The same holds for experience. It will probably only after a couple of years of teaching that the confidence towards teaching math will grow. If the current sample mainly contains young teachers, then the conclusion that experience has no influence on math anxiety might be wrong. Also, for the pre-service group, it is not reported in which year of their training they were. This is in my opinion also important information because of a strong selection takes place in the first years of educations (maybe math anxiety is much more present in the 1st year of teacher training, because the students with severe math anxiety will more likely fail for math related courses and therefore not pass.

Thank you for this comment. As stated by the Reviewer, we initially differentiated between pre- service and in-service teachers (and referred to it as experience). As such, experience was not related to math anxiety or teaching attitudes. Considering years of experience of teaching, as proposed by the Reviewer is indeed a very good idea. Obviously, there is no large difference in teaching experience for students, but we do have data and considerable differences in experience between the in-service teachers. Following the advice of the Reviewer, we analyzed the years of experience and its relation to attitudes towards math. Except for 1 missing data point, female in-

service teachers provided their experience as an elementary school teacher in years ( $N = 59$ ,  $M = 10.19$ ,  $SD = 10.44$ ,  $Mdn = 5$ ,  $Range = 0.5-38$  years). When exploring the data we did not find significant effects: The correlations of experience (in years) with math anxiety ( $r(59) = -.063$ ,  $p = .637$ ), enjoyment ( $r(54) = .011$ ,  $p = .935$ ) and ease ( $r(54) = .059$ ,  $p = .674$ ) of teaching math were not significant (even if considering only teachers without math specialization). These results support our conclusion that math anxiety in teachers does neither decrease nor increase with experience. We included this analysis in the manuscript.

Unfortunately, we cannot evaluate whether math anxiety differs between the beginning and the end of the studies in pre-service teachers, because we did not ask about the current year or semester of studies in our survey. We acknowledge this point in the revised manuscript. The only other proxy for experience level in both pre- and in-service teachers we might consider in our data is age: In line with our results, the correlations of age with math anxiety ( $r(223) = -.010$ ,  $p = .877$ ), enjoyment ( $r(182) = .009$ ,  $p = .182$ ) and ease ( $r(181) = .061$ ,  $p = .411$ ) of teaching math were also not significant (even if considering only pre-service teachers).

In response to the Reviewer, we would also like to discuss the suggestion on considering the grade the teachers are teaching. The focus of our study were elementary school teachers, which typically teach almost all subjects in grades 1-4 in Germany and in grades 1-6 in French-speaking Belgium. German teachers usually follow a class for the entire period of elementary school through different grades so that most of the German in-service teachers have experience with all grades in elementary school. On the other hand, French-speaking Belgian teachers usually teach only one certain grade so that it would make sense to assess the grade they are used to teach (but we do not have this data). Since the grade and the respective complexity of math content the teachers teach might impact on anxiety and teaching attitudes towards math (because it constitutes the type of teaching experience), we recommended further research on the topic.

Taken together, the experience level was not related to math anxiety or teaching attitudes, nor was age. These results do not contradict the conclusions of our paper but further support our claims. However, we acknowledge that we did not measure all possibly relevant variables for assessing experience in a more fine-grained manner. The following changes were made to the paper:

(1.1) The additional analysis on math anxiety was added to the Results: "To further explore the missing effect of experience on math anxiety, experience level (in years) was considered for female in-service teachers ( $N = 59$ ,  $M = 10.19$ ,  $SD = 10.44$ ,  $Mdn = 5$ ,  $Range = 0.5-38$  years). The Pearson correlation between experience level and math anxiety was not significant,  $r(59) = -.063$ ,  $p = .637$ ." (cf. p. 12)

(1.2) This result supports the claim made in the Discussion: "Thus, our results suggest that math anxiety might not fade away (or build up) with increasing teaching experience." (cf. p. 18)

(2.1) The additional analysis on teaching attitudes was added to the Results: "To further explore the missing effect of experience, the relation between experience level (in years) and teaching attitudes was analyzed by Pearson correlations for female in-

service teachers. Experience level did not significantly correlate with enjoyment of teaching,  $r(54) = .011$ ,  $p = .935$ , or ease of teaching math,  $r(54) = .059$ ,  $p = .674$ .” (cf. p. 15)

(2.2) This result was added to the Discussion: “However, in contrast to previous data (Hunt & Sari, 2019), our results provided no evidence of a beneficial effect of teaching math on the teachers’ attitudes, because female in-service and pre-service elementary school teachers did not significantly differ in enjoyment and ease of teaching math, and experience level in female in-service teachers did not significantly alter their teaching attitudes.” (cf. p. 19)

(3) To explicitly mention that the level of experience was only assessed in in-service teachers, but not in pre-service teachers, we added: “Note that similar data for pre-service teachers (e.g., years of teacher education) was not assessed in the current study.” (cf. p. 12)

(4.1) To further explain the considered educational systems, the grade levels were added to the Introduction: “In several educational systems, one teacher is in charge of teaching most of the subjects to their pupils in elementary school (grades 1 to 4/6).” (cf. p. 3)

(4.2) The grade the teachers are teaching in the context of math anxiety was considered in the Discussion: “Thus, it might not matter how much experience but which experience the teachers have (e.g., the grade and the respective complexity of math they typically teach).” (cf. p. 18)

(4.2) The grade the teachers are teaching in the context of teaching attitudes was considered in the Discussion: “As an open question, the different teaching experience regarding the grade and complexity of math might be addressed in future research.” (cf. p. 19 f.)

Second, in the paper only group analyses were reported, and as a group the teachers have higher levels of math anxiety compared to the control group. This does however not mean that they suffer from pathological levels of anxiety. Actually, when looking at the figures, the effect-size is rather small, so that you can wonder whether it had “clinical” significance. In the introduction it is frequently stated that math anxiety has a detrimental effect on math performance and teaching and creates the chance of a spillover of the anxiety towards children. Importantly, it is possible that healthy levels of anxiety can be advantageous (as it can motivate you to work harder). In this context, it is not sufficient to say that elementary school teachers have, as a group, higher levels of math anxiety. Given the presence of a relevant control group, it would be interesting to know how many in- and pre-service teachers score higher than e.g. pc. 90 of the control group. I think this information can provide additional interesting information to further strengthen the conclusions of the paper.

We thank the Reviewer for this idea. Although no diagnostic criteria exist for math anxiety yet (Cipora, Artemenko, & Nuerk, 2019), we considered the criteria for diagnosing dyscalculia (cut-off: 10<sup>th</sup> percentile) and for being at risk for dyscalculia (cut-off: 25<sup>th</sup> percentile), as suggested by the dyscalculia literature (Kaufmann et al.,



2009; Moeller, Fischer, Cress, & Nuerk, 2012). When applying these criteria for dyscalculia analogously to math anxiety, we will use the term “critical math anxiety” for percentiles over 90%, and “being at risk for critical math anxiety” for percentiles over 75%. We applied these criteria to categorize the teachers by their math anxiety according to the reference sample, and the results suggest again that math anxiety is a serious problem for female elementary school teachers without math specialization.

Results (text & table): “To further evaluate the math anxiety of teachers and the moderating effect of math specialization, we estimated the distribution of math anxiety in female elementary school teachers in relation to the reference sample of female students. Due to the lack of diagnostic criteria for math anxiety (Cipora, Artemenko, & Nuerk, 2019), we followed the suggestions for diagnosing dyscalculia (cut-off: dyscalculia  $\leq 10^{\text{th}}$  percentile; math anxiety  $> 90^{\text{th}}$  percentile) or being at risk for dyscalculia (cut-off: dyscalculia  $\leq 25^{\text{th}}$  percentile; math anxiety  $> 75^{\text{th}}$  percentile) in relation to normative data (reference sample) (Kaufmann et al., 2009; Moeller, Fischer, Cress, & Nuerk, 2012). This analysis shows that 12.56% of female teachers in our sample experience critical math anxiety and 33.63% at least are at risk for critical math anxiety (see Table 4). When considering specialization in math, only 4.65% of female teachers with math specialization experience critical math anxiety (24.03% are at least at risk), but 23.40% of female teachers without math specialization experience critical math anxiety (46.81% are at least at risk).” (cf. p. 13 f.)

Table 4. Distribution of math anxiety in female elementary school teachers (median, quartiles, 10<sup>th</sup> and 90<sup>th</sup> percentile of the female reference sample).

percentile norms		10%	25%	50%	75%	90%
		11	13	18	23	28
teachers	all	86.55%	77.58%	52.02%	33.63%	12.56%
	math specialization	80.62%	72.09%	43.41%	24.03%	4.65%
	no math specialization	94.68%	85.11%	63.83%	46.81%	23.40%

Note. The proportion of female teachers scoring above the given percentile norm of math anxiety was reported. The given percentiles include the 10<sup>th</sup> percentile (10%), lower quarter (25%), median (50%), upper quarter (75%) indicating risk for critical math anxiety, and 90<sup>th</sup> percentile (90%) indicating critical math anxiety. The given norms depict the AMAS scores that correspond to the percentile based on the distribution of AMAS scores in the reference sample of female German University students (N = 848).

Discussion: “This was supported by the prevalence of critical math anxiety being only half as large for female teachers with math specialization (about a quarter being at risk), but more than twice as large for female teachers without math specialization (almost half are at risk) as compared to female reference norms.” (cf. p. 18)

Conclusion: “In fact, almost half of these teachers [female teachers without specialization in math] could be classified as at risk for critical math anxiety, and almost a quarter as critically math anxious.” (cf. p. 21)

Abstract: “Importantly, female elementary school teachers without math specialization indeed had higher levels of math anxiety than female students from other fields and almost a quarter of them experience critical math anxiety.” (cf. p. 2)

We considered the idea of the Reviewer that math anxiety might not only lead to negative consequences, but also might motivate teachers to work harder. So we put the consequences into the perspective of various outcomes when discussing the implications of our results: “In sum, whenever elementary school teachers are afraid of math – and math anxiety does not motivate them, leading to positive consequences (Wang et al., 2015) –, there is a need for action to diminish the detrimental consequences for their students.” (cf. p. 20)

Where I fully understand that introducing more levels to certain variables (e.g. grade of teaching, years of experience) will give rise to lower numbers of participants in certain cells of the design, I’d like to hear the authors response to these issues and hope to be reassured that these factors do not fundamentally change some of the conclusion. As you can see below, some of the conclusions mentioned in the general discussion can, in my opinion, only be fully appreciated when this missing information is provided.

Please see above for our discussion on this issue.

Below I’ll give a “chronological” overview of the (minor) comments that came to my mind while reading the manuscript.

## Introduction

- P3 line 3: Strange formulation. If something has been shown in a meta-analysis, it should also be found in individual studies.

We rephrased the transition of the sentence accordingly (cf. p. 4).

- P3, line 17. Maybe it is interesting to mention the observed % of the different countries

The sentence on the average scores of teachers in relation to norms reports empirical studies from the USA and Canada, and the meta-analysis of Hembree (1990) also mostly reflecting data from these countries. Therefore, we added the general notion “(mostly from the USA and Canada)” in this sentence (cf. p. 4).

- P6, line 12: Can you be more specific with what you mean with math specialization? Are this additional math courses, or additional courses in how to teach math? Are these courses part of the curriculum? How is specialization in math during secondary education defined?

When German students study elementary school education, they usually choose majors among different subjects. In case of choosing math as a major, they attend more courses in math (both math courses focusing on content as well as math teaching courses focusing on pedagogy in math) as part of their curriculum and not only basic courses. French-speaking Belgian students usually have the possibility to



specialize in math during secondary school, which means that their time table includes more hours of math classes. We further explained the term “specialization in math” in the Methods as following:

“Specialization in math means that German teachers studied math as a major when deciding between different subjects, and thus took additional math courses and math teaching courses. For Belgian teachers it means that they specialized in math during secondary school, where they received an educational curriculum that contained a high number of math classes.” (cf. p. 7)

- P8 line 28 Were the subjects aware that their mathematical abilities were going to be measured? Was this indicated in the informed consent, or in the general description of study?

The title of the study included the term “math performance” and the informed consent informed the participants that they will be asked to solve some short math tasks. To make this procedure transparent, we added a short information in the Methods:

“Note that participants were notified at the beginning of their participation in the study that they would have to complete a mathematical performance task.” (cf. p. 9)

- P9 line 9. Please provide the average AMAS scores.

We added the means and standard deviations of AMAS scores for female teachers ( $M = 20.85$ ,  $SD = 7.25$ ) and male teachers ( $M = 15.54$ ,  $SD = 5.29$ ) to the Results (cf. p. 11).

- P10 line 2: Why are the results anecdotal and inconclusive, and how can this be seen in the figure and table?

The reference to the figure (displaying the effect) and to the table (for descriptive data) was unfortunate here and thus moved to the previous sentence. The categorization of the evidence for this effect as anecdotal and inconclusive is instead based on the Bayes Factor, which is only about 1. This is according to the categorization of Bayes Factors between 1 and 3 as indicating anecdotal evidence (Jeffreys, 1961; Lee & Wagenmakers, 2013). To clarify this connection, we changed the respective sentences as following:

“Math anxiety was significantly higher in female teachers compared to the reference sample,  $t(818) = 2.28$ ,  $p = .023$ ,  $d = 0.18$ ,  $BF_{10} = 1.11$  (see Figure 1A, Table 2; for the subscales learning math anxiety and math evaluation anxiety see the Appendix, Table A2). As indicated by the Bayes Factor of about 1, the evidence for this difference was only anecdotal and, in fact, the data were inconclusive, as the data are equally likely to occur under the alternative hypothesis and the null hypothesis.” (cf. p. 12)

- P11 figure: please indicate what the gray zone means.

In the violin plot, the gray zones indicate the distribution of the data based on a kernel density estimation. We added this information to the Figure legend (cf. p. 13).

- P14, line 7-8: “depending on specialization but not experience”, For this conclusion more information is needed about the years of education, grade where the type of specialization

The new analysis (see above) of experience level in in-service teachers did not provide significant effects, and therefore further supports this claim (cf. p. 17).

However, the grade in which they were teaching was not evaluated in this study, but mentioned in the Discussion: “Thus, it might not matter how much experience the teachers have but which experience they have (e.g., the grade and the respective complexity of math they typically teach).” (cf. p. 18)

- P15, line 20: “... might not fade away with increased teaching experience.” -> this conclusion only makes sense when you know the average age of experience.

The new analysis (see above) did not show a significant relation between experience level and math anxiety, and therefore supports this claim (cf. p. 18).

- P16 line 1: I think you have to be careful with this interpretation. There is a potential methodological problem. The the questions about joy and ease of teaching are asked at the end of the questionnaire. Isn't it possible that responses are biased by the anxiety questionnaire? People are sensitive to potential inconsistencies in their responses. I can't imagine that you will say that you enjoy teaching math a lot when you just indicated that math makes you anxious. Maybe you can mention this as a limitation of the study?

We added this limitation to the respective paragraph: “Given that the teaching attitudes were assessed only by single items and after math anxiety and performance in the current study, the results should be treated with considerable caution due to possible biases (e.g., teachers reporting their teaching attitudes more consistently to their math anxiety).” (cf. p. 19)

- P16, line 19: this conclusion can also only be fully appreciated if information about the level of experience and the grade in which they were teaching is known.

The new analysis (see above) did not show a significant relation between experience level and teaching attitudes. Therefore, it supports this claim: “However, in contrast to previous data (Hunt & Sari, 2019), our results provided no evidence of a beneficial effect of teaching math on the teachers, because female in-service and pre-service elementary school teachers did not significantly differ in enjoyment and ease of teaching math, and experience level in female in-service teachers did not significantly alter their teaching attitudes.” (cf. p. 19)

However, the grade in which they were teaching was not evaluated in this study, but was mentioned in the Discussion: “As an open question, the different teaching experience regarding the grade and complexity of math might be addressed in future research.” (cf. p. 19 f.)

## Second decision letter

Dear Christina Artemenko,

Thank you for your careful revision. Your article entitled "Not all elementary school teachers are scared of math" has now been accepted for publication in the Journal of Numerical Cognition (JNC) – congratulations!